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Cost-analysis of school-based fluoride varnish and fluoride rinsing programs

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Abstract

Objective. From a dental care perspective, we analyze whether the prevention of approximal caries by fluoride varnish treatment (FVT) or by fluoride mouth rinsing (FMR) could contain costs in an extended period of follow-up after the end of school-based prevention programs. ***Material and methods.*** It is assumed in a model that, after 3 years of prevention with either FVT or FMR according to published studies, the "natural course" of approximal caries progression would follow for 5 consecutive years, as described in a Swedish longitudinal study. The outcome and costs of FVT, FMR and controls were modelled from years 4 to 8. ***Results.*** The FVT program had a better outcome in reducing approximal caries than FMR, and costs were lower. The FVT was expected to result in cost containment compared to controls 3 years after the end of the preventive FVT program. The ratio benefits to costs were 1.8: 1 for FVT and 0.9: 1 for FMR. ***Conclusions.*** Prevention of approximal caries by FVT may result in cost containment, at a benefit cost ratio of 1.8: 1, given that the program can be administered at school.

Key Words: *Caries prevention, cost containment, cost-effectiveness, fluoride, modelling*

Introduction

Several empirical studies of caries prevention by fluoride varnish treatment (FVT) and mouth-rinsing (FMR) among children and adolescents have shown promising outcome [1–4], and some [5–7] have included economic aspects. With a short period of follow-up, empirical studies of prevention have not shown cost containment, i.e. a higher value of restorations prevented (benefits) than costs of the prevention program. However, one model study [8] covering a longer follow-up period has indicated that cost containment can indeed be achieved with prevention.

Some studies have shown that the beneficial effects from FMR cease when the rinsing period is over, which emphasizes the importance of a continuing supply of fluoride in maintaining a low caries incidence rate among schoolchildren [9,10]. In other studies, however, a lasting positive effect several years after discontinuation of FMR has been observed [11–13].

Using cost-benefit and cost-effectiveness analyses, Klock [5] evaluated a caries-prevention program comprising professional tooth-cleaning, dietary and oral hygiene instruction, topical fluoride application and fissure sealing in children in the 9–12 years age range. The result revealed that the prevention program cost more than three times that of traditional dental care.

In a cost-effectiveness analysis, Oscarson et al. [14] compared the costs and consequences of caries-prevention programs in high-caries-risk 12-year-olds from 26 different Dental Public Health Clinics throughout Sweden and revealed an annual cost of approximately SEK 334 (January to December 1999, average, USD 1 = SEK 8.27; Euro 1 = SEK 8.81) to

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avert one decayed enamel and dentin, missing and filled tooth surface (D_eMFS).

In a systematic review, an economic evaluation of dental caries prevention concluded that results for original FMR studies were contradictory [15]. As regards FVT, the conclusion was that there was no proof of cost-effectiveness or cost-containment [15], although one Swedish study did show positive effects [16].

The aim of the present study was to use modelling in analyzing whether the prevention of caries by FVT or FMR, compared to a control group, could result in cost containment in an extended period of follow-up, and whether there were indications that one form of prevention was more cost-effective than the other. In this modelling study, the conservative assumption was that the slope of the "natural course" of caries progression would take place after 3 years of prevention.

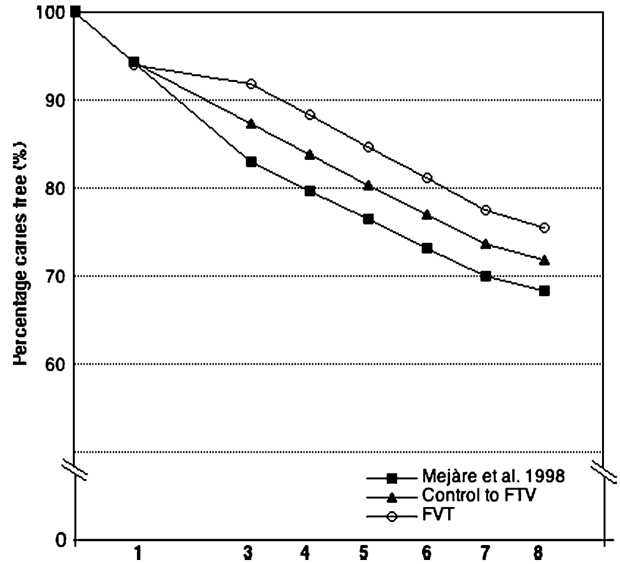

Figure 1. Percentage of approximal sites with no caries: the study by Mejàre et al. 1998 [19], control group and fluoride varnish treatment (FVT).

Material and methods

Studies of caries prevention

Two Swedish studies on the prevention of approximal caries have reported reductions in development of caries [17,18]. One was a randomized controlled trial [17] analyzing the prevention resulting from school-based FVT treatment, the other [18] involved a controlled study of the effects of school-based FMR.

The subgroup from the FVT study corresponded with the medium caries risk area; FVT was administered twice a year at 6-month intervals, i.e. a total of 6 times in 3 years. The corresponding group from the FMR study, which was conducted only in the medium-risk area, had rinsing administered on the first three and last three school days every semester, i.e. a total of 36 times during the 3-year study period. These two studies had the same control group in the medium-risk area.

FVT twice a year at 6-month intervals had a better caries prevention effect on caries incidence and caries progression on the approximal surfaces than supervised FMR on the first three and last three school days every semester (see Table I).

Modelling

A dental care perspective was used for this study. Modelling was based on decision-tree analyses (DATApro 4.0) and a spreadsheet analysis (Excel 2003). The model assumes a start from year 4 and is based on the Swedish longitudinal (12 year) study of the "natural course" of approximal caries progression in a normal school-based dental care environment [19]. It was assumed, after 3 years of prevention (either FVT or FMR), that the "natural course" of caries development would start, as described by Mejàre et al. [19]. In terms of percentage of approximal sites with no caries, the modelling is described in Figure 1, i.e. an assumed reduction parallel to that in the study by Mejàre et al. [19], from year 4 to year 8, was assumed for the

Table I. Caries incidence and caries progression after three years with or without school-based fluoride prevention according to Moberg Sköld et al. [17,18] (FVT = Fluoride Varnish Treatment; FMR = Fluoride Mouth Rinsing)

	FTV (n = 91) Mean (SD)	FMR (n = 133) Mean (SD)	Control (n = 94) Mean (SD)
New enamel lesions	0.52 (1.40)	0.64 (1.54)	1.52 (2.53)
New dentin lesions	0.02 (0.15)	0.02 (0.12)	0.06 (0.32)
Caries progression[1]	0.07 (0.29)	0.11 (0.88)	0.20 (0.60)
	Difference between fluoride group and control		
	FTV mean (CI 95 %)	FMR mean (CI 95 %)	
New enamel lesions	−1.01 (−1.60–0.41)	−0.88 (−1.42–0.35)	
New dentin lesions	−0.04 (−0.12 −0.03)	−0.05 (−0.11 − 0.01)	
Caries progression[1]	−0.14 (−0.27 −0.00)	−0.09 (−0.30 −0.12)	

[1]From enamel to dentin lesion.

FVT, FMR and the control group, respectively. Data from year 1 of the Mejàre study were also included in Figure 1.

A certain residual effect from the fluoride interventions can be expected for the year following the prevention programs, but this was not considered, and, as a result, a conservative estimate was included in the model. The development of approximal caries according to the study [19] was followed for 5 years from the end of the school-based prevention programs, i.e. a total period of 8 years.

The utility of caries prevention was defined as the monetary value of expected restorations prevented; the cost of prevention was thus compared with the utility (benefit) of prevention defined as expected prevented restorations until 5 years after the end of the prevention program.

With the filling material used today, there is a shorter medium survival time compared to amalgam fillings [20,21]. According to Forss et al. [22], 12% of fillings in permanent teeth were replacements of previous restorations, covering a period of 3.5 years. Thirteen percent of the restorations in the young permanent dentition had to be replaced over a period of 13 years because of secondary caries or fractures, as reported in a Swedish study by Wendt et al. [23]. The authors concluded that, for class-II restorations, the longevity of the resin restorations that failed corresponded to a mean of 3 years compared to 8–9 years for amalgam restorations. This same result was presented by Mjör et al. [24], i.e. the median longevity of failed composite restorations among adolescents was only 3 years, but this was not considered in the present study. For this reason, the model also assumed that restorations had to be replaced gradually. Combining the results of studies by Wendt et al. [23] and by Forss et al. [22] gives an average of about 2.5% per year of replaced restorations. Discounting to present value was based on a 3% discount level.

Resource utilization for school treatment FVT

In the FVT study by Moberg Sköld et al. [17], two dental nurses worked for 4 h; 1 h of this was spent preparing the treatments and for transportation between dental clinic and school. During the 3 h, two dental nurses worked simultaneously, which made it possible for 150 pupils to come from classrooms in groups of four to have FVT on their approximal surfaces. The pupils started with toothbrushing, and were then flossed and varnished in turn while lying down in the chair. When finished, another four pupils, who had already brushed their teeth, were ready for flossing and FVT. Each pupil received FVT twice a year, i.e. 6 times during 3 years.

Resource utilization for school treatment FMR

One dental nurse worked for 4 h, 1 h of which was spent preparing the rinsing and on transportation between the dental clinic and school, according to the FMR study by Moberg Sköld et al. [18]. During the remaining 3 h, the dental nurse supervised the rinsing in each classroom when 25 pupils rinsed with a 0.2% sodium fluoride solution for 1 min; in all, 9 school classes and a total of 225 adolescents. Each pupil received FMR on the first three and the last three schooldays every semester, i.e. a total of 36 FMRs during a period of 3 years.

Cost estimates

The cost of prevention for the different programs was calculated on the basis of statistics relating to the salaries of dental nurses, payroll taxes included (year 2005), observed use of the materials for FVT and FMR, respectively, as well as other materials as specified, estimated overheads and estimated cost of transportation for nurses (school-based programs), as described in Table II. Overheads of 11.85% according to one Swedish study [25] were included, assumed corresponding to costs of general management of the dental care clinics where the dental nurses worked. No cost for renting empty space at the schools was included. The cost of filling approximal caries lesions was estimated for the base care as corresponding to the official price at the Västra Götaland Region Public Dental Service for year 2005, i.e. SEK 826 per filling.

Sensitivity analysis

Different levels of costs and of outcome for the sensitivity analysis were included. The 95% confidence interval (CI) was used for outcome. The cost of each prevention program was estimated $\pm 20\%$ of base case cost. Also, it was to be studied at what reduced level (%) of the base case assumed price per filling that benefits and costs would still balance.

The progression of lesions to fillings, compared to the data of the empirical study used [19] to describe the "natural course" of caries progression, was to be reduced until a level of zero net present value was found. The discount rates of zero and 5% were included for the sensitivity analysis.

Statistical methods

Calculations of confidence intervals are specified in [17]. No calculations of significances of calculations were made, as the results were all based on modelling.

Results

According to the base case, the expected numbers of avoided fillings following reduced enamel caries

Table II. Estimated cost (SEK) of fluoride treatment at school (2006 price level)

Fluoride Varnish Treatment (FVT)			Costs (SEK)
2 dental nurses in team, 4 hours, 150 pupils per team; per pupil			11.20
Transportation to/from school, 12 km; per pupil			1.15
Utilization of materials per pupil			3.65
Duraphat 0.3 ml	2.30		
Dental floss	0,15		
Syringe	1.10		
Alcohol washing	0.10		
Overhead costs, 11.85%		1.90	
Estimated cost per pupil			17.90
Interventions per year: 2			
Estimated cost per pupil and year (FVT) (2 × 17.90 = 35.80)			35.80
Fluoride Mouth Rinsing (FMR)			**Costs (SEK)**
1 dental nurse, 4 hours, 225 pupils; per pupil			3.75
Transportation to/from school, 12 km: per pupil			0.20
Utilization of materials per pupil			0.75
NaF rinsing 10 ml	0.65		
Cup	0.10		
Overhead costs, 11.85%		0.55	
Estimated cost per pupil			5.25
Interventions per year: 12			
Estimated cost per pupil and year (FMR) (12 × 5.25 = 63.00)			63.00
Cost of dental nurse per hour			**Costs (SEK)**
Salary of dental nurse per month			19,200
Social security including holidays			10,900
Salary and added charges, per year			361,200
Cost of salary per year divided by working hours per year (= 1,720)			210.00

lesions and dentin caries lesions after 8 years, compared to the "natural course" of caries progression, are presented in Table III. Calculated per 100 pupils, 5 years after the end of the prevention program, the FVT was expected to have a better effect on reducing caries development than FMR. Calculated per 100 pupils, there were an additional 3.2 expected avoided fillings in the FVT group compared to the FMR group; the FMR group had 24.1 avoided fillings per 100 pupils compared to the control group during a period of 8 years.

Table III. Expected avoided fillings from reduced enamel caries and dentin caries lesions on the approximal surfaces, calculated for 100 pupils during five years following prevention program for years three to eight (FVT = Fluoride Varnish Treatment, FMR = Fluoride Mouth Rinsing)

	Number of avoided fillings		
Program	From enamel	From dentin	Avoided re-fillings
FVT	− 16.8	− 8.3	− 2.2
FMR	− 14.9	− 7.3	− 1.9

The expected cost of the FVT program, according to the base case, was 43% lower per year than that of the FMR program (Table II) and, as a result, the school varnish program was predominant, i.e. it produced a better outcome to lower cost.

Including costs of the prevention program, the expected economic outcome can be defined as the present value of cost of the prevention program compared to the present value of utility, expressed as the cost of avoided fillings. Calculated per 100 pupils, FVT at school was expected to produce a net result of SEK 8,521 after 8 years, which corresponded to a saving of SEK 315 per avoided filling, following the base case. According to the model, the present value of savings from prevented restorations would exceed the cost of the program during the sixth year, as shown in Figure 2.

According to the base case of the model, FMR at school was expected to produce a net present value of increased costs for 100 pupils of SEK 1,527 or SEK 63 per avoided filling. Figure 3 shows that a positive net present value of prevented restorations from FMR would be almost achieved during the last year included in the model.

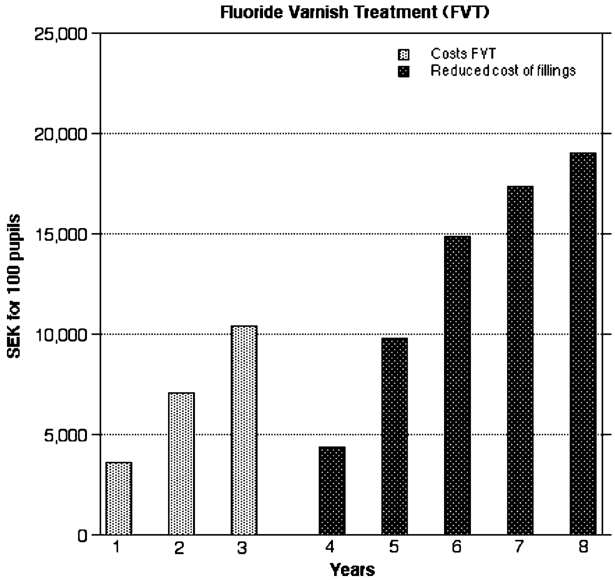

Figure 2. Fluoride varnish treatment (FVT) at school. Accumulated net present value of cost of varnish program compared to avoided cost of fillings. Calculated for 100 pupils.

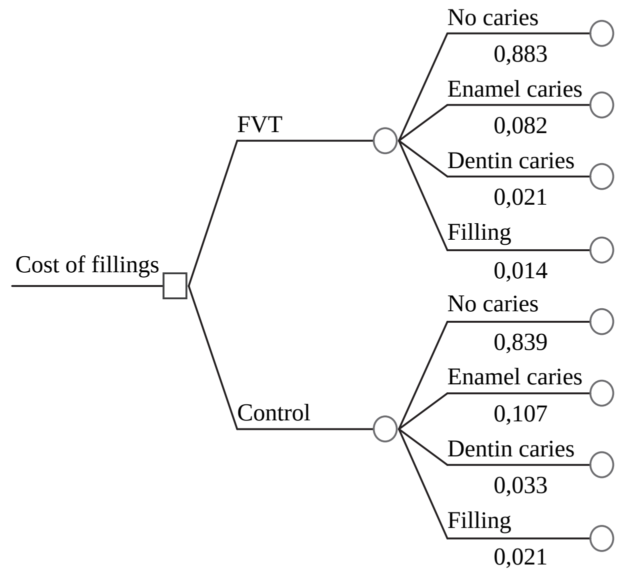

Figure 4. Fluoride varnish treatment (FVT) at school. Expected cost of fillings due to enamel caries and dentin caries, years 4 to 8. Calculated per pupil.

The importance of preventing enamel caries lesions as well as dentin caries lesions on the approximal surfaces was analyzed in a decision analysis using a decision tree modelling following the base case (Figure 4). Starting at year 4, and excluding differences of fillings during the first 3 years, the higher level of enamel caries and dentin caries will result in a higher average discounted cost of SEK 50 per pupil of the control group after 5 years, compared to those of the FVT group, i.e. SEK 269 compared to SEK 219. The amount corresponds to about 25% of the reduced costs of the FVT program compared to the control group.

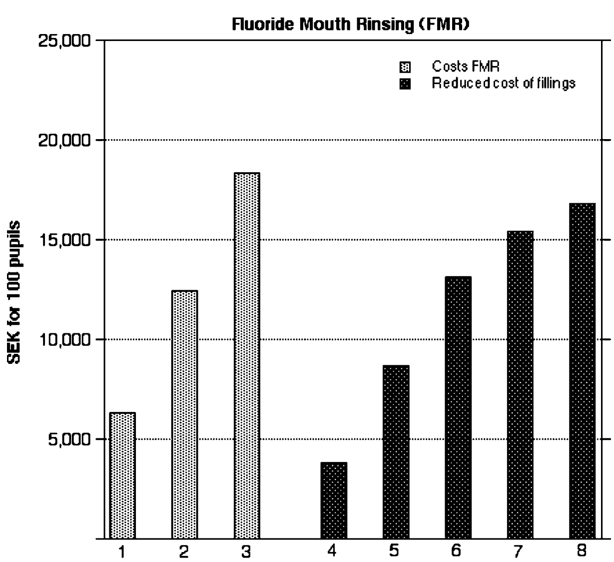

Figure 3. Fluoride mouth rinsing (FMR) at school. Present value of cost of rinsing program compared to avoided cost of fillings. Calculated for 100 pupils.

Sensitivity analysis

Varying the value of the expected restorations prevented within the limits of the confidence interval and assuming that the cost of each prevention program could vary ±20%, the FVT was expected to produce a positive net value, apart from an increase in the cost of the program of 20%, and an outcome for avoided fillings according to the minus 95% CI (Table IV). FMR would, however, result in a positive net value only at the +95% CI of avoided fillings, or at a 20% lower cost for the FMR program.

The expected level of a zero net present value, defined as the itemized cost of the prevention program that would make the expected present value of prevented restorations correspond to the present value of the prevention program, was reached at about SEK 65 for FVT, compared to about SEK 58 for FMR.

In case all enamel lesions would not turn into dentin lesions and then to restorations, the FVT would result in a zero net present value until a 40% reduction of the base case assumptions, i.e. that all lesions would lead to restorations.

Limiting the price of a restoration from SEK 826 to SEK 500 would result in a zero net present value for the FVT program.

For the FMR, benefits from prevented restorations and costs of the prevention program were not in balance even at the base case assumptions.

Changing the discount rate to 0% and 5%, respectively, had a more marginal effect on the net present value for the FVT, i.e. SEK –432 (saving) per prevented restoration at 0%, and SEK –279 at 5%, compared to SEK –314 at 3% (main alternative). In the case of FMR, the net present value per

Table IV. Reduced cost of fillings (net present value at 3% discount rate), SEK 2006. Sensitivity analysis using 95% confidence interval of outcome for fillings and variation in the itemized cost of the prevention programs of ±20%. (Comparison: January-December 2005, average, USD 1 = SEK 7.48; Euro 1 = SEK 9.28)

	Outcome as calculated	Outcome + CI 95%	Outcome – CI 95%
Fluoride Varnish Treatment (FVT)			
Calculated cost of program	8,521	19,988	792
Cost of program + 20%	6,500	17,904	−1,292
Cost of program – 20%	10,621	22,025	2,829
Fluoride Rinsing Treatment (FRT)			
Calculated cost of program	−1,527	8,561	−8,420
Cost of program + 20%	−5,194	4,894	−12,087
Cost of program-20%	2,141	12,229	−4,752

avoided filling was SEK –43 at 0% and SEK +97 (increased cost) at 5%, compared to SEK 63 at 3%. The main finding was thus confirmed, i.e. that FVT resulted in possible cost containment and FMR in added cost, except for the 0% discount rate.

Discussion

We combined the results of a longitudinal study of the development of caries in schoolchildren [19] with studies of caries prevention programs at schools using fluoride supplements [17,18] to a model study. The expected present value of outcome defined as avoided fillings was compared to the present value of the fluoride prevention programs. The FVT program was superior to the FMR program, and the FVT was even expected to result in possible cost containment, when also considering most alternatives in the sensitivity analysis. However, reducing the price of a restoration from SEK 826 to 500, or assuming that only 60% of the lesions would result in restorations, the FVT program would reach a zero net present value.

The possibility of cost containment was also suggested in a model of sealant strategies by Griffin et al. [26]. In a Markov model, Quiñonez et al. [27] showed from modelling that sealing the 1st permanent molars can improve outcome and save money by delaying or avoiding invasive treatments. When it comes to the FMR, if the annual cost of FMR was 8% less than calculated, the FMR would reach break-even, i.e. the benefit of avoided fillings would correspond to the cost of prevention after 8 years, all expressed as present values.

However, neither FVT nor FMR included any cost for the school space capacity that was used, as vacant rooms were used. The FVT program could probably also support cost of using room capacity, since the calculated itemized cost was only about 55% of the level at which benefits and costs would balance, according to the base case.

In the study by Källestål et al. [28], the cost of preventing dental caries was calculated at SEK 244 for 4 years for the 12-year age group, expressed at 1991 price levels. Recalculated per year, and using the Swedish Consumer Price Index for the period 1991 to 2005 to inflate costs, the cost would be SEK 81.75 per year. The latter includes the total dental clinic costs, i.e. also cost of renting room space, overheads and similar costs. In the study by Källestål et al. [28], 83% of the total cost consisted of the cost of salaries and material, i.e. SEK 67.85 ($0.83 \times 81.75 = 67.85$), which resembles the cost of FMR per year in our study. Based on the same study [28], including rent and depreciation of dental equipment would increase the cost by 7.3%. If applied to our study, the cost of rent and depreciation would correspond to SEK 2.61 and SEK 4.60 for FVT and FMR, respectively.

Our study had a dental care perspective, i.e. no costs contributed by the patient or the patient's family. However, Källestål et al. [15] showed that societal costs are high and ought to be considered. If so, the benefits from our model would increase the cost containment.

In current Swedish dentistry, the demand for increased productivity is high, and the legacy tends to promote conservative treatment rather than prevention. However, for the individual, the value of healthy teeth and good oral health might be higher than the cost of a filling [29]. The willingness of 19-year-olds to pay (WTP) for caries prevention measures was studied. The Net Societal Benefit was >0 when WTP was included (SEK 1,087 for low-risk groups), which means that benefits exceeded the cost of prevention. Healthy teeth without fillings mean that the individual is free from pain, has the benefit of a dentition completely free from decay and, in the long run, improved occlusion, the psychological value of retaining teeth, avoidance of extractions and/or surgical dentistry. These aspects of quality of life for the individual are important for future dental health care. Prevention at school means that pupils lose less school time compared to going to a Public Dental Clinic. Furthermore, there is a risk that students will not turn up at the clinic, since there is low compliance for prevention treatment for risk patients [19], and the parents do not need to worry about transportation for their children. For the dental staff, there is less administration time, i.e. no calling patients, fewer patients not turning up for treatment and the capacity of treatment rooms at dental clinics can be used for patients in greater need of more intensive prevention or surgical dentistry. Further improvements in school-based programs of FMR and FVT seem likely, and may reduce the cost per treated pupil thus making school-based interventions even more cost-effective.

The conclusion of this study is that a model based on empirical data makes it plausible that a fluoride varnish program at school is more cost-effective than a fluoride rinsing program and that a fluoride varnish program may even imply cost containment. Expressed as a ratio of expected benefits (prevented restorations) to costs (of prevention program), we had 1.8: 1 and 0.9: 1 for FVT and FMR, respectively.

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